(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 743 422 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
18.02.1998 Bulletin 1998/08

(43) Date of publication A2:
20.11.1996 Bulletin 1996/47

(21) Application number: 96303392.3

(22) Date of filing: 14.05.1996

(51) Int Cl.6: E21B 33/129

(84) Designated Contracting States:
DE FR GB NL

(30) Priority: 16.05.1995 US 442448

(71) Applicant: HALLIBURTON COMPANY
Duncan Oklahoma 73536 (US)

(72) Inventors:
- Branch, Alton L.
Comanche, Oklahoma 73529 (US)
- Smith, Donald R.
Wilson, Oklahoma 73463 (US)
- Berscheldt, Kevin T.
Duncan, Oklahoma 73533 (US)

(74) Representative: Wain, Christopher Paul et al
A.A. THORNTON & CO.
Northumberland House
303-306 High Holborn
London WC1V 7LE (GB)

(54) Downhole packing assembly

(57) A downhole tool apparatus such as a packer or bridge plug, has a mandrel (49), slip means (20) on the mandrel (49), a packer element (29) on the mandrel (49), a packer element retaining shoe (50) made of non-metallic material and comprising a plurality of shoe segments (51) and means (52) for retaining them in an initial position on the mandrel. Such non-metallic packer element shoes do away with troublesome prior art metallic shoes and backups, and thus increase the ease of drilling or milling downhole tools out of a well bore.

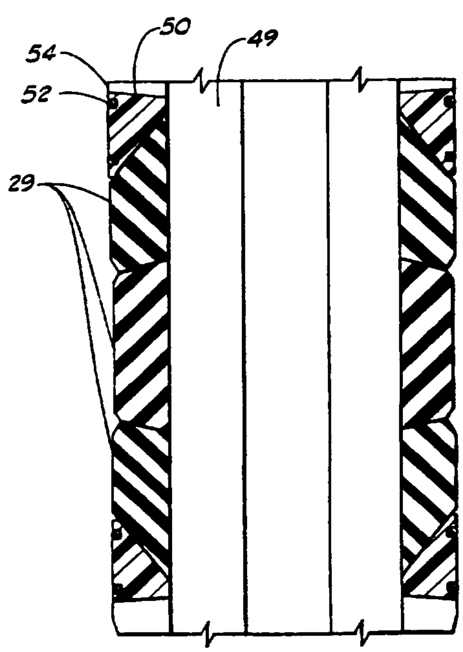

FIG. 5

EP 0 743 422 A3

(Cont. next page)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 30 3392

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X,D Y	US 5 271 468 A (STREICH) * column 3, line 25 - line 30 * * column 7, line 66 - line 67 * * claim 9 * * column 6, line 68 - column 7, line 4 * ---	1-3,5-8 4,9,10	E21B33/129
Y	US 5 234 752 A (LAFLIN) * the whole document * ---	4	
Y	US 2 059 901 A (PARRISH) * page 1, right-hand column, line 52 - page 2, left-hand column, line 11 * ---	9,10	
X,D	US 5 390 737 A (JACOBI) * the whole document * ---	1-3,5-8	
X	US 4 708 202 A (SUKUP) * column 7, line 23 - line 34 * * column 7, line 47 - line 51 * ---	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	US 3 907 033 A (STUCHLIK) * the whole document * ---	4	E21B
A	US 2 966 216 A (BIGELOW) * the whole document * ---	9,10	
A	US 5 174 397 A (CURRINGTON) * column 5, line 42 - line 52 * ---	10	
A	US 1 707 659 A (HALL) * page 1, line 107 - line 108 * ---	9	
A	US 3 497 003 A (BERRYMAN) * the whole document * ---	1	
A	GB 2 140 879 A (HUGUES TOOL COMPANY) * claim 4 * --- -/--	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	30 December 1997	Sogno, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 743 422 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
20.11.1996 Bulletin 1996/47

(51) Int Cl.6: E21B 33/129

(21) Application number: 96303392.3

(22) Date of filing: 14.05.1996

(84) Designated Contracting States:
DE FR GB NL

(30) Priority: 16.05.1995 US 442448

(71) Applicant: HALLIBURTON COMPANY
Duncan Oklahoma 73536 (US)

(72) Inventors:
- Branch, Alton L.
Comanche, Oklahoma 73529 (US)
- Smith, Donald R.
Wilson, Oklahoma 73463 (US)
- Berscheidt, Kevin T.
Duncan, Oklahoma 73533 (US)

(74) Representative: Wain, Christopher Paul et al
A.A. THORNTON & CO.
Northumberland House
303-306 High Holborn
London WC1V 7LE (GB)

(54) **Downhole packing assembly**

(57) A downhole tool apparatus such as a packer or bridge plug, has a mandrel (49), slip means (20) on the mandrel (49), a packer element (29) on the mandrel (49), a packer element retaining shoe (50) made of non-metallic material and comprising a plurality of shoe segments (51) and means (52) for retaining them in an initial position on the mandrel. Such non-metallic packer element shoes do away with troublesome prior art metallic shoes and backups, and thus increase the ease of drilling or milling downhole tools out of a well bore.

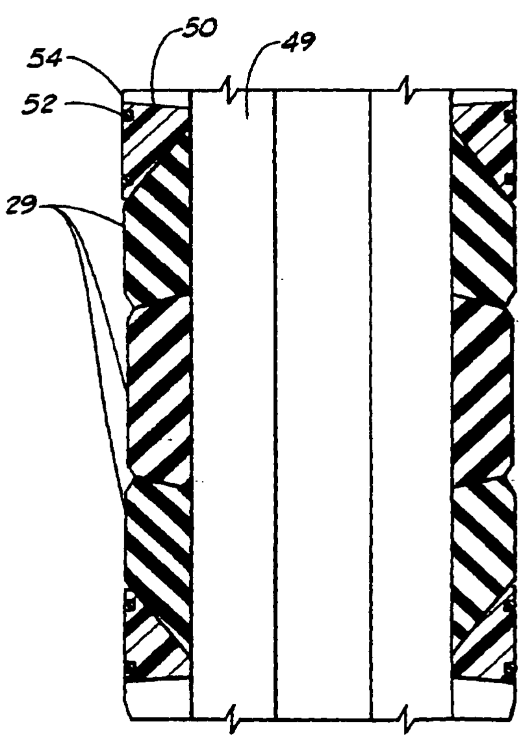

FIG. 5

EP 0 743 422 A2

Description

This invention relates generally to a downhole apparatus for use in a wellbore, and particularly but not exclusively to downhole packer and bridge plug tools.

In the drilling or reworking of oil wells, a great variety of downhole tools are used. For example, but not by way of limitation, it is often desirable to seal tubing or other pipe in the casing of the well, such as when it is desired to pump cement or other slurry down the tubing and force the slurry out into a formation. It then becomes necessary to seal the tubing with respect to the well casing and to prevent the fluid pressure of the slurry from lifting the tubing out of the well. Downhole tools referred to as packers and bridge plugs are designed for these general purposes and are well known in the art of producing oil and gas.

When it is desired to remove many of these downhole tools from a well bore, it is frequently simpler and less expensive to mill or drill them out rather than to implement a complex retrieving operation. In milling, a milling cutter is used to grind the packer or plug, for example, or at least the outer components thereof, out of the well bore. Milling is a relatively slow process, but when milling with conventional tubular strings, it can be used on packers or bridge plugs having relatively hard components such as erosion-resistant hard steel. One such packer is disclosed in our U.S. Patent No. 4,151,875 to Sullaway, and sold under the trademark EZ Disposal packer.

In drilling, a drill bit is used to cut and grind up the components of the downhole tool to remove it from the well bore. This is a much faster operation than milling, but requires the tool to be made out of materials which can be accommodated by the drill bit. Typically, soft and medium hardness cast iron are used on the pressure bearing components, along with some brass and aluminum items. Packers of this type include the Halliburton EZ Drill® and EZ Drill SV® squeeze packers.

The EZ Drill SV® squeeze packer, for example, includes a lock ring housing, upper slip wedge, lower slip wedge, and lower slip support made of soft cast iron. These components are mounted on a mandrel made of medium hardness cast iron. The EZ Drill® squeeze packer is similarly constructed. The Halliburton EZ Drill® bridge plug is also similar, except that it does not provide for fluid flow therethrough.

All of the above-mentioned packers are disclosed in Halliburton Services - Sales and Service Catalog No. 43, pages 2561-2562, and the bridge plug is disclosed in the same catalog on pages 2556-2557.

The EZ Drill® packer and bridge plug and the EZ Drill SV ® packer are designed for fast removal from the well bore by either rotary or cable tool drilling methods. Many of the components in these drillable packing devices are locked together to prevent their spinning while being drilled, and the harder slips are grooved so that they will be broken up in small pieces. Typically, standard "tri-cone" rotary drill bits are used which are rotated at speeds of about 75 to about 120 rpm. A load of about 5,000 to about 7,000 pounds of weight is applied to the bit for initial drilling and increased as necessary to drill out the remainder of the packer or bridge plug, depending upon its size. Drill collars may be used as required for weight and bit stabilization.

Such drillable devices have worked well and provide improved operating performance at relatively high temperatures and pressures. The packers and bridge plugs mentioned above are designed to withstand pressures of about 10,000 psi (700 Kg/cm^2) and temperatures of about 425° F (220°C) after being set in the well bore. Such pressures and temperatures require using the cast iron components previously discussed.

However, drilling out iron components requires certain techniques. Ideally, the operator employs variations in rotary speed and bit weight to help break up the metal parts and reestablish bit penetration should bit penetration cease while drilling. A phenomenon known as "bit tracking" can occur, wherein the drill bit stays on one path and no longer cuts into the downhole tool. When this happens, it is necessary to pick up the bit above the drilling surface and rapidly recontact the bit with the packer or plug and apply weight while continuing rotation. This aids in breaking up the established bit pattern and helps to reestablish bit penetration. If this procedure is used, there are rarely problems. However, operators may not apply these techniques or even recognize when bit tracking has occurred. The result is that drilling times are greatly increased because the bit merely wears against the surface of the downhole tool rather than cutting into it to break it up.

In order to overcome the above long standing problems, we introduced to the industry a line of drillable packers and bridge plugs currently marketed under the trademark FAS DRILL. The FAS DRILL line of tools consist of a majority of the components being made of non-metallic engineering grade plastics to greatly improve the drillability of such downhole tools. The FAS DRILL line of tools have been very successful and a number of U.S. patents have been issued to us including U.S. Patent 5,271,468 to Streich et al., U.S. Patent 5,224,540 to Streich et al., and U.S. Patent 5,390,737 to Jacobi et al. Reference should be made to these patents for further details.

Notwithstanding the success of the FAS-DRILL line of drillable downhole packers and bridge plugs, we have discovered that certain metallic components still used within the FAS-DRILL line of packers and bridge plugs at the time of issuance of the above patents were preventing even quicker drill out times under certain conditions or when using certain equipment. Exemplary situations include milling with conventional jointed tubulars and in conditions in which normal bit weight or bit speed could not be obtained. Other exemplary situations include drilling or milling with non-conventional drilling techniques such as milling or drilling with relatively flex-

holding the shoe segments in place after initial assembly and during the running of the tool into the wellbore and prior to the setting of the associated packer element within the well bore. The preferred packer shoe assembly of the downhole tool disclosed herein further consists of packer shoe segments preferably being made of a phenolic or a composite material to withstand the stresses induced by relatively high differential pressures and high temperatures found within wellbore environments.

In order that the invention may be more fully understood, various embodiments thereof will now be described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 is a cross-sectional view of a prior art downhole packer apparatus depicting prior art packer show assemblies having the preferred slips and slip assemblies that can be used in connection with the present invention.

FIG. 2A is a front view of the preferred slip shown in FIG. 1 that can be used with the present invention.

FIG. 2B is a cross-sectional side view of the preferred slip segments shown in FIG. 2A.

FIG. 2C is a top view of the preferred slip segments shown in FIGS. 2A and 2B.

FIG. 3A is top view of the preferred slip wedge shown in FIG. 1 and can be used with the present invention.

FIG. 3B is a cross-sectional side view of the preferred slip wedge shown in FIG. 3A.

FIG. 3C is an isolated sectional view of one of the multiple planar surfaces of the slip wedge taken along line 3C as shown in FIG. 3A.

FIG. 4 is a cross-sectional side view of an alternative prior art packer element retainer shoe.

FIG. 5 is a cross-sectional side view of the preferred packer element retainer shoe of the present invention.

FIG. 6A is a top view of the preferred packer shoe and retaining band of the present invention. The retaining band is shown in an exageratedly expanded for clarity.

FIG. 6B is a cross-sectional side view of the packer element shoe shown in FIG. 6A.

Referring now to the drawings. FIGS. 1 - 4 are all of prior art and have been provided for background and to show the preferred embodiment of a tool in which the present invention is particularly suitable for, but not limited to.

FIG. 1 is a prior art representation of a downhole tool 2 having a mandrel 4. The particular tool of FIG. 1 is referred to as a bridge plug due to the tool having a plug 6 being pinned within mandrel 4 by radially oriented pins 8. Plug 6 has a seal means 10 located between plug 6 and the internal diameter of mandrel 4 to prevent fluid flow therebetween. The overall tool structure, however, is quite adaptable to tools referred to as packers, which typically have at least one means for allowing fluid communication through the tool. Packers may therefore allow for the controlling of fluid passage through the tool by way of a one or more valve mechanisms which may be integral to the packer body or which may be externally attached to the packer body. Such valve mechanisms are not shown in the drawings of the present document. The representative tool may be deployed in wellbores having casings or other such annular structure or geometery in which the tool may be set.

Tool 2 includes the usage of a spacer ring 12 which is preferably secured to mandrel 4 by pins 14. Spacer ring 12 provides an abutment which serves to axially retain slip segments 18 which are positioned circumferentially about mandrel 4. Slip retaining bands 16 serve to radially retain slips 18 in an initial circumferential position about mandrel 4 as well as slip wedge 20. Bands 16 are made of a steel wire, a plastic material, or a composite material having the requisite characteristics of having sufficient strength to hold the slips in place prior to actually setting the tool and to be easily drillable when the tool is to be removed from the wellbore. Preferably bands 16 are inexpensive and easily installed about slip segments 18. Slip wedge 20 is initially positioned in a slidable relationship to, and partially underneath slip segments 18 as shown in FIG. 1. Slip wedge 20 is shown pinned into place by pins 22. The preferred designs of slip segments 18 and co-acting slip wedges 20 will be described in more detail herein.

Located below slip wedge 20 is at least one packer element, and as shown in FIG. 1, a packer element assembly 28 consisting of three expandable elements positioned about mandrel 4. At both ends of packer element assembly 28 are packer shoes 26 which provide axial support to respective ends of packer element assembly 28. Backup rings 24 which reside against respective upper and lower slip wedges 20 provide structural support to packer shoes 26 when the tool is set within a wellbore. The particular packer element arrangement show in FIG. 1 is merely representative as there are several packer element arrangements known and used within the art.

Located below lower slip wedge 20 are a plurality of multiple slip segments 18 having at least one retaining band 16 secured thereabout as described earlier.

At the lowermost terminating portion of tool 2 referenced as numeral 30 is an angled portion referred to as a mule-shoe which is secured to mandrel 4 by radially oriented pins 32. However lowermost portion 30 need not be a mule shoe but could be any type of section which serves to terminate the structure of the tool or serves to be a connector for connecting the tool with other tools, a valve, or tubing etc. It should be appreciated by those in the art, that pins 8, 14, 16, 22, and 32, if used at all, are preselected to have shear strengths that allow for the tool be set and to be deployed and to withstand the forces expected to be encountered in a wellbore during the operation of the tool.

As described in the patents referenced herein, the majority of the components in tool 2 of FIG. 1, with the

tained and supported the respective ends of the associated packer elements. Thus it is fully expected that pressures reaching 10,000 psi (700 Kg/cm^2) and temperatures reaching 400° (205°C) are obtainable using shoes embodying the present invention. The subject test shoes were initially retained by a pair of retaining bands as described herein and made of a composite material obtained from General Plastics as referenced herein. The associated packer element ends were inspected after the test was performed and found to be in a satisfactory condition with only expected non-catastrophic deformation of the packer element assembly present.

Returning now to FIGS. 2 - 4 of the drawings. Although, it is admitted that slip segments 18 and slip wedges 20 are prior art, it is preferred that the subject slip segments and slip wedges be constructed as discussed below in order to take full advantage of features and benefits of downhole tools constructed essentially of only non-metallic components as discussed herein.

However, it is not necessary to have the particular slip segment and slip wedge construction shown in FIGS. 2 - 4 in order to practice the present invention, as the disclosed packer element shoes can be used in connection with any type of downhole tool employing at least one packer element whether or not the tool is made essentially of only non-metallic components or a combination of metallic and non-metallic components.

Preferably, slip segment 18 as shown in a front view of the slip segment, denoted as FIG. 2A, has an outer external face 19 in which at least one and preferably a plurality of inserts 34 have been molded into, or otherwise secured into, face 19. Inserts 34 made of zirconia ceramic have been found to be particularly suitable for a wide variety of applications. Slip segment 18 is preferably made of a composite material obtained from General Plastics as referenced herein in addition to the materials set forth in the present Assignee's patents referenced herein.

FIG. 2B is a cross-sectional view taken along line 2B of slip segment of 18 FIG. 2A. Slip segment 18 has two opposing end sections 21 and 23 and has an arcuate inner mandrel surface 40 having topology which is complementary to the outer most surface of mandrel 4. Preferably end section surface 23 is angled approximately 5°, shown in FIG. 2B as angle θ, to facilitate outward movement of the slip when setting the tool. Slip segment bearing surface 38 is flat, or planar, and is specifically designed to have topology matching a complementary surface on slip wedge 20. Such matching complementary bearing surface on slip wedge 20 is designated as numeral 42 and can be viewed in FIG. 3A of the drawings. A top view of slip segment 18, having a flat, but preferably angled, top surface 23 is shown in FIG. 2C. Location and the radial positioning of sides 25 define an angle α which is preselected to achieve an optimal number of segments for a mandrel having an outside diameter of a given size and for the casing or well bore diameter in which the tool is to be set. Angle α is preferably approximately equal to 60°. However, an angle of α ranging from 45° to 60° can be used.

Returning to FIG. 2B, the sides of slip segments 18 are designated by numeral 25. It is preferred that six to eight segments encircle mandrel 4 and be retained in place prior to setting of the tool by at least one, and preferably two slip retaining bands 16 that are accommodated by circumferential grooves 36. Slip retaining bands 16 are made of composite material obtained from General Plastics as referenced herein or other suitable materials such as ANSI 1018 steel wire available from a wide variety of commercial sources.

Referring to FIG. 3A, a top view is provided of preferred slip wedge 20 having flat, or planar, surfaces 42 which form an opposing sliding bearing surface to flat bearing surface 38 of respectively positioned slip segments 18. The relationship of such surfaces 38 and 42 as installed initially are best seen in FIG. 2B, FIG. 3C, and FIG. 1. As can be seen in FIG. 3C, which is a broken away sectional view taken along line 3C shown in FIG. 3A. It is preferred that slip wedge bearing surface 42 be defined by guides or barriers 44 to provide a circumferential restraint to slip segments 18 as the segments travel axially along slip wedge 20 and thus radially outwardly toward the casing or well bore during the actual setting of the packer tool. Preferably angle β, as shown in FIG. 3B is approximately 18°. However, other angles ranging from 15° to 20° can be used depending on the frictional resistance between the coacting surfaces 42 and 38 and the forces to be encountered by the slip and slip wedge when set in a well bore. Internal bore 46 is sized and configured to allow positioning and movement along the outer surface of mandrel 4.

It has been found that material such as the composites available from General Plastics are particularly suitable for making a slip wedge 20 from in order to achieve the desired results of providing an easily drillable slip assembly while being able to withstand temperatures and pressures reaching 10,000 psi (700 Kg/cm^2) and 425°F (220°C). Additionally, suitable material includes the materials set forth herein and in the present Assignee's patents referenced herein.

A significant advantage of using such co-acting flat or planar bearing surfaces in slip segments 18 and slip wedges 20 is that as the slips and wedges slide against each other, the area of contact is maximized, or optimized, as the slip segments axially traverse the slip wedge thereby minimizing the amount of load induced stresses being experienced in the contact area of the slip/slip wedge interface. That is as the slip axially travels along the slip wedge, there is more and more contact surface area available in which to absorb the transmitted loads. This feature reduces or eliminates the possibility of the slips and wedges binding with each other before the slips have ultimately seated against the casing or wellbore. This arrangement is quite different from slips and slip cones using conical surfaces because when us-

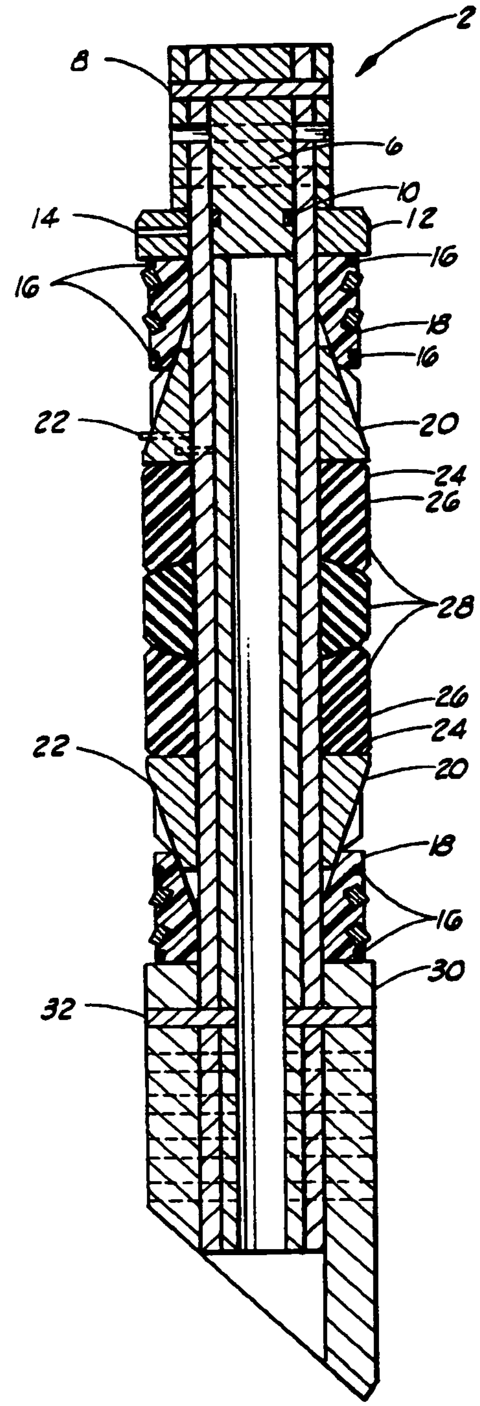

FIG. 1
PRIOR ART

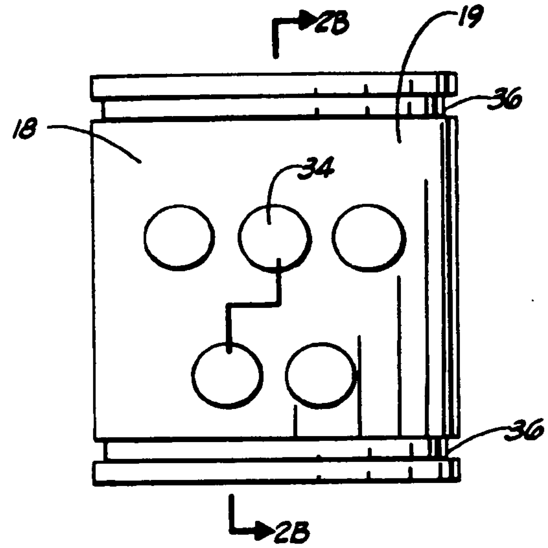

FIG. 2A
PRIOR ART

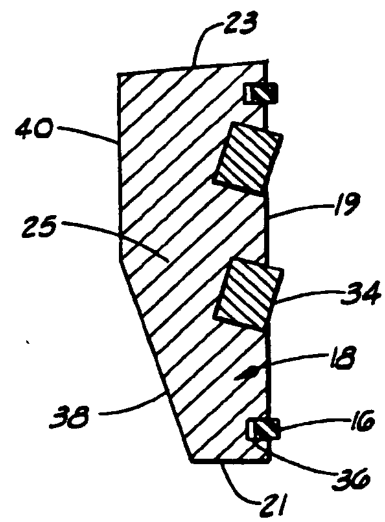

FIG. 2B
PRIOR ART

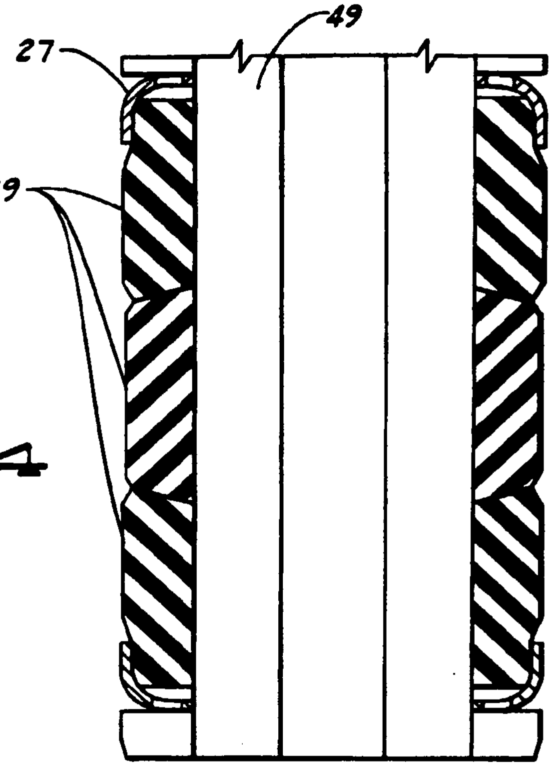

FIG. 4
PRIOR ART

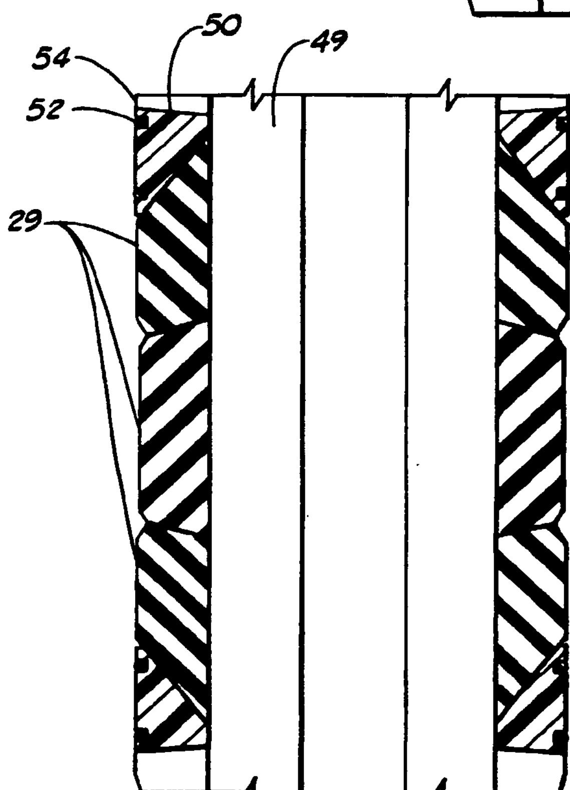

FIG. 5